

**REPORT RELATIVE TO THE GENERATION AND ARTIFICIAL
FECUNDATION OF OYSTERS, ADDRESSED TO THE MINISTER
OF THE MARINE AND THE COLONIES.***

By M. BOUCHON-BRANDELY,

SECRETARY OF THE COLLEGE OF FRANCE.

Since the creation of the ostracultural industry, the administration of the marine has not ceased by divers means, grants of money, missions, etc., to encourage all attempts having for their object the development of this industry. It is undoubtedly to this that ostraculture owes its present prosperity and the constant progress it has realized, a progress which was shown in so worthy a manner at the exposition at Bordeaux.

Faithful to this tradition, you have been good enough, monsieur, to authorize us, under your auspices and with your encouragement, to make the investigations of which we herewith present an account.

These researches commenced in the College of France in 1880, in the laboratory of comparative embryogeny, under the direction of M. Balbiani, the eminent successor of M. Coste, who has aided us with his counsel, have been pursued in this same laboratory and upon different points of our coast, and they relate to:

1. The sexuality of the French oyster (*Ostrea edulis*) and the Portuguese oyster (*Ostrea angulata*).
2. The fecundation, the incubation, and the development of the eggs and embryos of both species.
3. The possibility of interbreeding [crossing] them.
4. The artificial fertilization of the Portuguese oyster.

This outline report does not permit us to give the questions which we have studied that extended consideration which they deserve, so as to touch upon all their aspects; we will have the honor, however, of shortly presenting to you a more complete report on this subject. We now occupy ourselves more particularly with our experiments in the artificial fecundation of the Portuguese oyster; these are what appear to us to be of the most immediate interest.

THE PORTUGUESE OYSTER.

The mollusk known under the name of the Portuguese oyster has not existed upon our coast for more than thirty years. The Museum Delessert, Lamarek collection, possesses the only specimen which we

* *Rapport relatif à la génération et à la fécondation artificielle des huîtres, adressé au ministre de la marine et des colonies, par M. Bouchon-Brandely, secrétaire du Collège de France. Journal officiel de la République Française. December 16 and 17, 1882, pp. 6762-6764 and 6778-6782. Translated, with notes, by JOHN A. RYDER.*

have. Its introduction and acclimation into our waters are due entirely to an accidental cause. A vessel coming from Portugal brought back a cargo. Entering the Gironde after a long voyage, the captain thinking the oysters were dead had the whole ship-load thrown into the water, on an old bed called the Banc du Richard. Having found in the Gironde a medium almost identical with that from whence they came, and the conditions favorable to their propagation, they have there multiplied in such proportion that from the Pointe de Grave to beyond Banc du Richard, that is for an extent of nearly 30 kilometers, they form a vast bed, the extent of which will soon be limited only by the banks of the river.

The natural history of this mollusk has been imperfectly known, and the accounts of it are very vague. We may compare them with the common oyster, from which they differ as follows: 1, in their form; 2d, in the taste of their flesh; 3d, in their habits; 4th, in respect to their sexuality.

It is superfluous to here describe their external form, in that it does not recall that of *O. edulis*.

As to the taste or flavor, no confusion is possible to a palate in the least experienced. As to their habits, we know that they delight in brackish and muddy waters, and that there they multiply in preference to all other situations. We find them, in fact, in the Gironde, in the approaches to the Île d'Oléron, at the mouth of the Charente, where the waters have a specific gravity of between $1\frac{1}{2}$ to 3 degrees (1.009 to 1.020). They still multiply in the Basin of Arcachon but meagerly, and only in such places where they are sensible of the influence of fresh water. It is fitting in this connection to allude to a singular phenomenon at that place; it is, that the oyster of the Tagus there becomes infertile after a certain length of time, to such an extent that they soon disappear in the basin if a complement of sexually mature individuals are not brought there at intervals to perpetuate the species.

In respect to sexuality, the difference between these two mollusks is very great; most radical. *Ostrea edulis* is hermaphrodite; *O. angulata* is unisexual or dioecious. We have opened more than 10,000 in all phases of reproductive activity, and we have not seen a single one of the latter of which the sex was doubtful. They were all either exclusively male or exclusively female.

No less marked is the difference in the mode of reproduction. The eggs of the common oyster are fecundated within the valves of the parent, apparently within the openings of the oviducts; those of the Portuguese species on the bosom of the waters. The first cannot develop outside of the incubatory cavity of the parent; the second undergo their development in the open currents. The larvæ of *O. edulis*, in order to live, develop and attain the errant or pelagic stage of their existence, are dependent upon the albuminous liquid secreted by the mother; those of *O. angulata*, more vigorous, more independent, and altogether

more active, transport themselves into the living waters to there take up the nutritive matters which are necessary to transform them into spat.

HYBRIDIZATION.

There are, therefore, great differences between the Portuguese and common oyster of our coasts, not only from a conchological point of view—that is to say, in respect of external form—but also as regards their malacological and embryological peculiarities. The characters of each are so well marked that the question of hybridization, which has so alarmed our maritime population, would not have needed to be raised. We understand that, according to a preconceived theory of certain culturists, these two rival species of oysters are susceptible of crossing.

The Portuguese, on the one hand, tending to abase the purity of our race of oysters; on the other, on account of its fecundity and vitality to replace the common oyster, to invade our banks, to ruin our propagating parks. This prediction has happily not been realized, and our oysters, also those of Arcachon, those with the fine and nacreous shells of some of the rivers of Bretagne, the green oysters of Marennes, the deep-water oysters grown on the sands of d'Olonne, have lost nothing of their purity and primitive qualities. We consider it useless in this place to state the weighty reasons which impel us to combat this theory.

We would simply remark in this place that it is now nearly thirty years since the Portuguese oyster has been introduced into the waters of Arcachon. If they have exercised the influence which has been supposed upon the native oysters of the basin, we cannot find any evidence at this ostracultural station of a single individual which shows the effect of hybridization.

On the other hand, not a single bed can be cited where they have caused ruin and diminution of fertility. Have they injured the oysters of Arcachon? The marshes not transformed into parks; the canals of the basin, are they less productive than in times past? The banks of Brittany, still so rich (the Portuguese oysters have been cultivated in the rivers of Auray and La Trinité), have they suffered in the least? Does the dredger of to-day encounter many Portuguese or hybrid oysters? No. These fears, we repeat, are not justified, and this for the reason already stated, that the two rival bivalves live and are adapted to entirely different environments. Moreover, the following experiments demonstrate scientifically the inanity of the doctrine of hybridization.

The surest means of discovering if cross-fertilization would take place consisted in bringing into contact the generative elements of the two species participating, or supposed to, in this act. It is in this way also that we should proceed when we would learn if the individuals of allied species or varieties of the same species are susceptible of concurring in the production of a being. Very often, when closely allied species or varieties of the same species were used, the cross-fertilization would not end in the production of living embryos. The elements sometimes

blended properly and fecundation took place; sometimes also the ovule would segment and attain a more or less advanced degree of development, etc.; but when these same elements were brought into immediate contact they remained unchanged, and ended in absolute sterility.

This is precisely what we have observed in the course of direct attempts at hybridization which we have made during the past two years—last year and this.

At different times and under different conditions we have brought the eggs of the Portuguese oyster and the milt of the common oyster into contact, and *vice versa*; never under these experimental conditions, the sexual elements not being brought into contact naturally, has there been a trace of evidence of successful fertilization or of development.

ATTEMPTS AT ARTIFICIAL IMPREGNATION.

When after two years we had learned for a certainty that the sexes of *Ostrea angulata* were confined to separate individuals, we immediately conceived that it was possible to artificially fertilize the eggs of this mollusk. We were likewise encouraged by the experiments which Brooks, of the Johns Hopkins University of Baltimore, had made upon *Ostrea virginica*, likewise unisexual, and which had enabled him to follow the development of the embryos to the formation of the shell.

We began some experiments in the laboratory of embryogeny of the College of France, which, without being conclusive, indicated none the less the path to be pursued, and the manner in which our experiments were to be conducted. In the course of the same year these experiments were repeated at Arcachon without much success. Last year we obtained mobile larvæ for the first time. The observation much surprised us; we had not long to wait, for after an incubation of only twelve hours, a precocious outward manifestation of life was apparent, for already in this phase of their evolution these larvæ presented an appearance which left no doubt as to their definitive form.

On the other hand, we have found nothing in what has been published on the subject of the incubation and transformation of the eggs of *Ostrea edulis* which recalls the aforementioned phenomenon of precocious movement which had not, we believe, been observed before.* The advanced state of the season where we were, and the difficulties which we had to procure Portuguese oysters at Arcachon in a condition fitted for spawning purposes, did not permit us to continue the

* At the time when they occupied themselves busily with the artificial fecundation of fish ova, the two Vosgian fishermen, Gohin and Rémy, sought to discover, or had stated that it would be possible to treat the eggs of the common oyster, the only native species known at that time, by the same methods. But the hermaphroditism of the mollusk having been demonstrated, they were obliged to abandon this hope. Moreover, had the artificial fecundation been possible, it would have been of no consequence industrially, for the reason that the eggs and embryos of *Ostrea edulis* cannot develop outside of the incubatory cavity of the parent.

experiments profitably, nor to settle those questions which were still obscure. At the end of last season we little thought, considering the slowness with which our studies had progressed, that we would be able in a single campaign to solve the problem of artificial fertilization applicable to the ostracultural industry; we were also not at first assured of our ability to produce the manifestation of the phenomena which we have observed with so much interest and upon which rested our hope of final success.

In recommencing the work we were obliged to make choice of a convenient station for our experiments. The station of Verdon, situated on the left bank of the Gironde, at a distance of several kilometers from the mouth of the river, seemed to us to combine all the desired advantages. We were assured of finding there the oysters fitted for spawning, as well as suitable water. In fact, the first attempt which we made in artificial impregnation in fourteen hours afterwards resulted in the production of mobile larvæ, notwithstanding that the season for the fry had not yet arrived, commencing at least a month later.

M. Tripota, one of the veteran ostraculturists, and at the same time one of the most competent, very willingly, at the request of the commissioner, M. Jouan; placed at our disposal, with a grace and disinterestedness for which we are under great obligations, two beautiful unsubmersible claires which received fresh water for several days during the spring tide, and which were soon arranged for our use by means of some slight internal alterations. Separated from each other by a straight, massive wall of earth, these two ponds, with an area of about 100 meters each and an average depth of 80 centimeters to 1 meter [27 inches to 3 feet], were placed in communication by means of a pipe, which was closed at either end by a sponge to keep out any sediment in suspension in the water. In this manner all doubt as to the origin of the spat which was collected was guarded against.

For the outlet, an apparatus consisting of a wall of fine sand confined by boards permitted the water to percolate through it, but prevented the embryos from escaping with it. The lowermost claire only was utilized in our experiments. The uppermost claire, in which we stored the water whenever it was possible, served as a reservoir from which to decant, the supply-pipe allowing nothing to pass into the experimental claire except clear water.

This arrangement completed, the products of artificial fecundation, impregnated in various ways, were poured into the experimental reservoir. This took place in the second week in June.

According to our belief, we hoped to find some spat on the collectors placed in the experimental claire at the end of the same month or by the beginning of the month of July. M. Tripota, who had taken an active part in the work, and who took my place in my absence, continued to supply the claire with fertilized eggs and mobile embryos.

The time assigned for experimental proof having arrived, the collect-

ors were examined, but they did not bear any apparent trace of spat. This was a deception. Meanwhile, thinking that the season for the fry had not yet begun in the Gironde, we expected happier results from our final experiments. The claire was emptied, and some modifications were introduced in the management of the water, and from day to day mixtures of the generative products were again poured into the claire.

On the 24th July the tiles were examined. This time all had spat attached. It was therefore evident that the first experiments had not been as unsuccessful as we had supposed. In fact, each of the tiles immersed had young oysters attached to the number of twenty or thirty, measuring about a centimeter [two-fifths of an inch] in diameter. This spat was evidently derived from the spawn put out during the end of June or the commencement of July; but their small size had prevented us from seeing them when the inspection was made at that time. On the 24th July we had specimens about a month old. This fact was all the more remarkable, in that, up to that same time, the collectors placed in the Gironde, in the very center of the spawning beds, did not show a sign of spat.

The problem which we had put before ourselves had accordingly received, from a scientific and practical point of view, a solution in conformity with our hopes. It was possible to obtain spat by means of artificial fecundation and to capture it in confined waters. And we no longer had the slightest reason to doubt the identity of that which had caught on our tiles, nor to suppose that it came from the waters without, since there was as yet none apparent in the Gironde, and the tiles in the upper claire, which served to feed the experimental claire, were completely exempt.

If in forcing nature's processes we arrive at the same result, that is, provoke the birth of the young before the time of the normal emission of the spawn, there is all the more reason for us to suppose that we have an excellent means to aid and favor her.

In pursuing our researches in the establishment of M. Tripota, we did well to vary our means of investigation whenever the same bore upon the industrial aspects of the work.

On the rights [parks] along the Canal du Conseiller, and fed by it, there exist old salt marshes, for the most part abandoned, or used for other purposes than formerly, some of which have been transformed into reservoirs for fishes. Those which we appropriated were about two kilometers from the river and from the locality chosen at Verdon, and received fresh supplies of water during the spring tides. They consisted of numerous compartments, varying in depth and communicating by wide trenches cut into the banks separating them from each other. Their total extent somewhat exceeded a hectare. During the new and full moon the gate controlling the supply was opened to allow the fish carried by the current to enter and to renew the water. This maneuver was repeated many times during the tide. On account of the situation

occupied by this marsh along the exposed shores of the Gironde the water is never stagnant, even at the time of the neap tides. The sea-breezes and winds which follow the course of the river aerate it perpetually and agitate its surface. Those which we had chosen measured 5 to 6 feet in depth at the center and 2 to 3 along the margin. Stakes placed at intervals supported the fragments of tiles suspended with iron wire.

From the beginning of July to the end of August, M. Gassiau, school-master at Verdon, who assisted us during the entire campaign, with an intelligence, zeal, and devotion worthy of the highest praise, took care to pour into the inclosures, several times a week, the products of the artificial fecundations which he prepared with rare skill and certainty. Three hundred oysters only were used in these experiments.

On the 8th of August he visited the collectors, and observed on all of them, without exception, hundreds of young oysters, measuring one-half to two millimeters in diameter [$\frac{1}{5}$ to $\frac{1}{2}$ of an inch]. The spat grown from each of the successive lots of fertilized spawn could be distinguished by its size, which corresponded to its age. Having the curiosity to know how many fixed themselves to one tile, we counted more than eight hundred on a single piece of tile, of which the size was one-fifth that of an entire one. This time our success was complete.

Up to the end of August, the time when the oysters had nearly all spawned, the spat continued to attach itself just as abundantly to all kinds of collectors with which it came in contact indiscriminately, fragments of tiles, pieces of wood, boards, &c.

Doubt was no longer possible. The pessimists asked whether our nurslings would grow and develop equal to those which were naturally collected on the banks of the Gironde. We responded to this objection by sending some of the tiles to be placed in the parks at Arcachon, where they remained for a month and a half.

These tiles and fragments of tiles figured at the end of September in the exposition at Bordeaux by the side of those which had been brought by MM. Tripota and Gassiau.

We also found that the spat born in the beginning of July, in the closed *claire*, measured from three to four centimeters in diameter, and that which was collected in the salt-marsh by the end of July and during the month of August had attained the dimension of one centimeter [two-fifths of an inch] in diameter. Finally, during the early part of October, we had the honor of presenting to the minister of marine a tile upon which two thousand young oysters could be counted, measuring from one to two centimeters [two-fifths to four-fifths of an inch] in diameter.

It now remained for us to make a final demonstration. It was necessary to prove that the spat which was collected did not primarily emanate from the banks in the Gironde, but was the result of the artificial fecundations practiced under our care. This proof was evi-

dently superfluous after what had taken place in the closed and poorly aerated waters of the *claire* where we had in the first place established ourselves. We knew, in fact, that the person who cultivated the marsh had attempted in vain, two or three years before, to collect spat. But, in undertaking this counter-experiment, we had a two-fold object in view, viz, to clear up all doubts, if such still existed, as to the value and advantages of the method of artificial fecundation, and that of creating a sentiment in its favor. This proof had to be conclusive.

At the entrance to a fish-pond close to the one used by us, of nearly the same extent, similarly arranged and receiving water from the same canal, had been placed the tiles upon which it was thought the spat coming from the river would not fail to attach itself. At that time the oysters were in the height of reproductive activity; the collectors in the Gironde were being charged with spat, and ours in the other pond were being covered as fast as and in the proportion that they were immersed. We expected to find some young oysters on the collectors put down as a test. There was nothing on them, however; these collectors remained completely free of all traces of spat.

THE METHODS OF ARTIFICIAL FERTILIZATION.

Imperfect and incomplete as our methods of artificial fertilization still are, we think it useful to make them known. In fact, there is no better way perhaps to aid in bringing them to that perfection of which they seem to be susceptible. After many trials and experiments, we have found the following to be the most practicable:

It is easy, after a little practice, to determine the sex of the Portuguese oyster with the naked eye. A small portion of the matter contained in the genital gland is taken and placed on a plate of glass and diluted with a quantity of sea-water many times in excess of the volume of the portion of spawn.

When the subject is female, the liquid appears granular, and upon examining it with care we see the ovules which the water has set free or separated. If it is a male, the mixing of the water with the seminal fluid is more difficult, and the liquid remains opaque and milky. With the aid of a pocket lens the distinction is very easily made.

The choice of spawning individuals is not, we have reason to think, a matter of indifference to the success of the operation. We would reject for this purpose oysters from shallow water or such as are frequently uncovered by the tide.* We have never obtained good results

* Our belief as to the sterility of certain brood-oysters rests upon two very important observations made at the island of Oléron. It was in vain that we attempted to fertilize the spawn of oysters taken from the higher levels of the oyster grounds of the island, while at the same time, under the same conditions, in the same medium, with the same water, and under the same external influences, the experiments resulted in the formation of mobile embryos, if spawners were used from the same shore, but from deeper water. We would, however, make certain reservations in this regard.

with them. The fecundation is effectual, cleavage sometimes proceeds to an advanced stage, but all at once the development is arrested, the eggs undergo alterations, and their membrane ruptures.

To avoid all inconveniences of this kind it is best to use spawners taken from active and deep waters. It is also important to assure one's self that the sexual products used are quite mature. In the absence of any means of verification by means of the microscope, an instrument possessed by few ostraculturists, the following methods are to be resorted to: First, by an inspection of the genital gland. If it is transparent at one point, it shows that the evacuation of the generative products has commenced, and that consequently those elements are mature. (This remark applies to the gland of the male as well as to that of the female.) Secondly, by freeing the eggs from the ovary. If the eggs are easily detached, by simply stroking with a fine camel's-hair pencil, we may consider them fitted for fertilization. It seems, however, that infertile ovules detach themselves easily from the gland, but that this does not take place unless the spawning oysters have been injured.

Finally we find that the seminal liquor seems to act most efficiently when it mixes readily with the water.* This disposition noted, and after having prepared a vessel one-half or one-third full of sea-water, an incision is made in the ovarian gland, and we detach the eggs by means of a soft, flexible brush or pencil, from which they are deposited in the vessel as fast as they are removed. We find that their impregnation is facilitated if they are subjected to a washing at this time.

This operation purges them of impurities which are still adherent, and brings about the dissociation of those which still stick together. With this object we shake the contents of the vessel with the hand or stir them with the pencil, when the liquid is allowed to settle. In one-half to one hour afterwards the uninjured ova have settled at the bottom of the vessel; that which remains in suspension in the water; vitelline matters, ruptured membranes, injured eggs, &c., is to be poured off. It is of advantage to repeat this process of decantation.

The seminal liquor [milt] is obtained by the same means as the eggs, but there is no necessity for any preliminary preparation. It is simply

*The microscope is now of the greatest utility, if we wish to assure ourselves of the quality of the fertilizing element. This element, in order that it may serve its purpose satisfactorily, when examined with a sufficiently strong magnifying power, it is necessary that the animalcules of which it consists should appear segregated, independent, and active. During cold weather they are often immobile, but they are often only benumbed; it is then only necessary to expose them to warm air or place them in water at a temperature of 22° C. to 25° C. (71° F. to 77° F.), in order to cause them to vibrate and display activity. Segregation of the spermatic particles may be produced under certain circumstances by the same process. Cases of infertility of the milt are generally very rare. [The segregation or dissociation of the seminal particles or spermatozoa by diluting the sperm with water is an important fact, and one that has thrust itself upon the notice of the translator in observing the fresh milt of both oysters and fishes. It seems quite inactive in some cases before dilution; its activity is then at once provoked by the addition of water.—Tr.]

poured into the same vessel with the latter, impregnation taking place at once.*

From that moment the successive phenomena of development are not easy to follow under the microscope. We find, after the generative elements are brought into contact, that the egg, which was at first pear-shaped, becomes more and more nearly round; the germinative vesicle is effaced and disappears totally, the polar globules appear at one point on the periphery, the egg segments into two, three, and four parts, the number of which goes on increasing until it finally assumes the mulberry or morula form. In order to clearly describe the transformations of the egg, it would be necessary to have illustrations appended. In the course of seven or eight hours of incubation, according to the temperature, the embryos begin to move, and a mobile larva appears.†

The mobility of the larva is manifested in accelerated movements of rotation or by sudden starts across the field of view in which they are observed. Sometimes they rotate as if on a pivot, sometimes they remain quite immobile; but if we examine them with care we find that the vibratile cilia with which they are provided continually manifest their peculiar motions. Arrived at this period of their existence, and in consequence of their small size, they become difficult to observe.‡ We have observed the rudiment of the shell at about the seventh day of development. [This is sometimes formed in twenty-four hours in the American species.—Tr.]

Fertilization will succeed without conforming rigorously to the directions which we have given. The determination of the sexes, for example, is not absolutely necessary, for, in operating with a certain number of sexually mature adults, it is certain that both males and females will be found amongst them. The same remark applies to washing the eggs; but we would insist that it is a useful precaution which has real advantages and facilitates the study of the phenomena of development.

* According to the observations made in the laboratory of M. Balbiani by M. Henneguy, the egg of *Ostrea angulata* appears to be provided with a micropyle at its point of attachment to the follicle, that is to say, at the extremity of its pedicle.

† At Verdon we have obtained mobile embryos seven hours after the fecundation, with the water at a temperature of 22° C. (71° F). [The eggs of the American oyster, with the water at 78° F. to 80° F., will hatch in five hours.—Tr.]

‡ The volume of the larva is about equal to the egg. Now, the egg of *Ostrea angulata*, if we suppose it to be perfectly spherical, and we take the smallest diameter of this sphere, measures 52 millimeters [$\frac{1}{16}$ th of an inch]; the volume is consequently .073584th of a cubic millimeter.

For the sake of comparison, measurements of the following species are appended:

The unisexual oyster of Dackar; diameter of the egg, 43 millimeters.

The hermaphroditic oyster of Toulon (*Ostrea plicatula*); diameter of the egg, 95 millimeters.

The common oyster (*O. edulis*), hermaphroditic; diameter of the egg, 122 millimeters.

We would add, in conclusion, that the generative elements may be preserved for some hours, without being brought into contact, and not lose any of their vital properties. Our collaborators have obtained the best results when the generative products were not mixed together for one or two hours after they were removed from the glands.

We will close this part of our essay with allusions to some observations relative to, first, the influence apparently exercised by the density of the water on the process of fertilization; secondly, artificial incubation. The water employed at Verdon had a density of about two and a quarter to three degrees, measured by the hydrometer [or an indicated specific gravity of about 1.014 to 1.020 of Baumé's scale, the one probably used.—Tr.]

At Cette, the waters of the Mediterranean were successfully used; the specific gravity in this case was nearly 4 degrees [or nearly 1.027].

In the present condition of our researches it is difficult to reach any conclusion in regard to the facts just recorded, particularly the two preceding. It does not seem any the less certain that if the oysters will not be able to become sexually active in very saline waters, it does not appear that such waters are inimical to fertilization and development. [This was not the experience of the translator with the spawn of the American oyster. It was found in fact that water of a markedly higher specific gravity than that from which the spawning adults was taken was injurious, especially to the milt.—Tr.]

In respect to the attempts at artificial incubation, we would say that we have employed [temperature] methods similar to those used in incubating birds' eggs. The eggs of the oysters placed in water maintained at a uniform temperature of 20° C. [68° F.] were hatched in six and a half hours. It would be profitable to make experiments in this direction; for, if the method of artificial incubation is successful as applied industrially, it would be carried on at all times, except during cold, stormy weather, which kills both the eggs as well as the larvæ. With our present processes the incubation as well as the fertilization are not very successful, except when the weather is warm and fair.

APPLICATION OF ARTIFICIAL FECUNDATION.

Is it necessary to have recourse to the economy of artificial methods, in view of the evidence in favor of its advantages, opening up, as it does, a new field in the ostracultural industry?

The Portuguese oyster is endowed with surprising fertility.* If all of

* A cubic centimetre of ovary yields:

	Ova
By the method of dissociation.....	2,500,000
By the method of section.....	5,200,000
Total	7,700,000
(Mean, 3,850,000.)	

The volume of the ovary of an oyster of medium size varies between 6 and 8 cubic

the eggs annually produced by the innumerable individuals to which the Gironde affords protection would hatch out, and if also the waters of the river contained sufficient food to nourish them, the adjacent portions of the sea would soon be filled up. The causes of the destruction are numerous and powerful, for the crop of fry is always abundant, and either in consequence of inclement weather or during high winds, tempestuous waves disperse and destroy the legions of larvæ which are in process of incubation. Now, the methods which we extol would enable us to escape some of these evils, and would assure those who put them in practice of a certain crop, by protecting the fry from the fluctuations of the temperature, and by this means persisting bad weather would not compromise the regular abundance.

We have already remarked that it is not a single crop of fry which we have each year, but two, and perhaps three. In fact, the season for the fry lasts for at least three months. This interval is sufficient, we have learned with certainty, at Verdon, to permit us to place the collectors three times in the same claire, when the fry will adhere each time.

The localities adapted for the hatching establishments are not wanting; they are to be found near the mouths of most of our rivers. Two conditions only are necessary: the waters should be brackish and have a specific gravity of 1.014 to 1.020, and be readily renewed.

Perhaps it would serve us much better to show up the advantages of our system by borrowing some data from fluvial fish-culture.

We know with what success we now treat the eggs of fishes by methods of artificial fertilization, of which M. Coste determined and stated the laws. The cause of the depopulation of the waters is the want of proper economy; and it may be said that in every European state the question of fish-culture is the order of the day, and takes the first rank amongst those economical questions claiming prompt solution. To this end special laboratories for the practice of fish-culture have been established in Switzerland, Germany, England, Russia, Norway, etc. Artificial fertilization is the *raison d'être*, and is the basis of their operations. These have given results much superior to those which are obtained by allowing nature to have her own way. For example, of 1,000 eggs fertilized artificially and cared for in hatching boxes, 980 hatch perfectly, while of those left to themselves in the open waters it is estimated that 90 per centum are lost.

We admit that the eggs of the salmonoids are much better adapted, on account of their large size, to artificial treatment, than those of *Ostrea angulata*; but even if this comparison is hardly fair, the diminished losses which would result from the application of artificial

centimetres. There are consequently about 20,000,000 eggs discharged annually by an oyster three to four years old.

In the case of the common oyster (*O. edulis*) this number is reduced to 1,200,000 to 1,500,000 eggs.

methods to the eggs of the unisexual oysters would none the less be a fruitful operation. We see what occurs under natural conditions. The mother oyster discharges its eggs in considerable numbers. But how many are there of those which in the immensity of the surrounding waters find favorable conditions for their life? The estimation of the losses is difficult, but if we base our calculation upon the proportions indicated above, we will find that of the twenty millions of eggs produced during one season but two millions ever attain the condition of mobile larvæ.

Once brought to this phase of transformation, how many attach themselves to the collectors? There is little hope that more than a tenth part escape the manifold dangers by which they are constantly surrounded. In the closed claires it is otherwise. We at once guarantee the impregnation of all the fertilizable eggs, placed as they are in forced contact with the fecundating element. There is thus suppressed the prime cause of the destruction of germs, without doubt the most important. We also escape a second and also serious cause of mortality, in protecting the embryos in the closed reservoirs, where, sheltered from dangers of all kinds to which they are exposed without, they pass undisturbedly through the period of their pelagic existence, till the time when they find themselves in need of the collectors, which they will readily find, and to which they will fix themselves.

Figures will be more eloquent than many arguments; *one hundred fertilized eggs have produced eighty mobile larvæ*. This is the mean result of our experience at Verdon. Considered in its industrial relations, the system of capturing the fry in closed waters would be infinitely more economical than the present system.

The only collectors suitable for great depths are the tiles, which, on account of their weight, oppose a resistance to the currents; boards, slates, and other light bodies have been successively abandoned. But the tiles are raised with difficulty after they are disposed in nests on the beds. They are put out only when the fry is abundant, or when it is being discharged during certain tides and favorable times.

In confined waters [claires] we could put down or remove the collectors at any phase of the moon, no matter what might be the state of the sea, without incurring the risk of breaking them. Nor would it be necessary to fix them to the bottom. Moreover, we would not employ tiles exclusively, for, while the tile is an excellent collector, it also has its disadvantages, especially on the shores of the Gironde, where this mode of rearing the oyster is not in favor. Since their great weight renders their transportation costly, they remain in position only till the spat may have reached the size necessary for *detrocage* [or detachment], from which cause the growth of the spat is delayed for a year.

Not to neglect any of the aspects in which ostraculture may perhaps be viewed, permit us to say that the following methods appear practicable: Firstly, the introduction and acclimation in our waters of uni-

sexual species of oysters, like those of Dakar, America, etc.; secondly, the establishment of beds at different places known to be favorable along our coast.

This work of colonization would present no very great difficulties, nor would it entail a very heavy expense. This might be carried out at the mouth of one of our rivers—the Charente or Adour, for example, the mouths of which are known to be well adapted as breeding and hatching basins. In these reservoirs during three months we would pour the fertilized products of thousands of oysters, and allow the resulting embryos to disperse themselves freely in the river. If the collectors, tiles, stones, or shells were then spread on the bed of the river, a bank would soon be formed; and if they repeat this operation for two or three years, this bank will be sufficiently important to become an object of regular and productive improvement.

CULTURE.

Our experiments in propagation have for their necessary complement the study of the question of culture. We are now assured of no lack of the spat of the Portuguese oyster. The culturists of Verdon who furnish it need have no anxiety about finding sale for what is collected during the spawning season. Arcachon will take a large quantity, and we need scarcely observe that its employment will render it possible to utilize lands supposed to be unproductive, and also abandoned parks which have been found not adapted to the culture of the common oyster. Their cultivation is still practiced in some places on the island of Oléron, and in some of the claires of the Seudre and of La Rochelle. But the area devoted to this special industry is necessarily very limited, because, in spite of the favorable reports on the culture [education] of the oyster of the Tagus, the culturists do not appear disposed, at present at least, to abandon, in preference to the latter, the culture of the French oyster.

It is now important to find suitable fields for the exercise of the energies of the maritime population; to find sites suitable for the establishments of which we are in need.

We have extended our survey in part over our sea-coast, where portions of the beach still remain unused, and in part along the shores of the Mediterranean, where we encounter a vast chaplet of lagoons, which are separated from the lake of Berre, where they do not terminate, however, and after a short interruption of continuity end at the lake of Le Canet.

At the sea-shore we would designate some places along the Charente and Adour, and particularly certain plains in the valley of the Gironde, where, as at Verdon, the industry is almost entirely neglected. The opinion of the inhabitants of this coast is, that the culture of the oyster is there neither possible nor advantageous. This opinion has no found-

dation in fact, because it is not possible to doubt that the Portuguese oyster will thrive in any medium favorable to it. Such an opinion would be contrary to the teachings of natural history. We believe also that, in the Lower Medoc district, they will at some future time collect their spat in the Gironde. Meanwhile the intelligent culturists are boldly immersing on the beds in the river thousands of collectors, which are rapidly covered with young oysters. This example is bearing fruit. This year the park-culturists of Verdon have put down 120,000 tiles. Next year their imitators will be more numerous.

It would be the same with the rearing (*élevage*) of the oyster, and if some one would make an initial attempt, with the proper means, it would be found that the grounds of Verdon, the nature of which is similar to those of Arcachon, where the Portuguese oyster, after detachment from the collectors, grows to an edible size in a year and a half, would produce oysters equal to those of the latter place in size and fatness. Up to the present the oyster industry of Verdon has simply limited itself to the following: To fish and dredge up every year whatever of oysters have accumulated on the beds and concessions, and transport them as promptly as possible to the cultural stations.*

It is true that the attempts at culture, in the manner urged by us, have not here given the best results. The oysters do very well at first in the claires and marshes, but if their stay is prolonged, they soon sicken. What is the cause of their decline? All those who have had experience in ostraculture would say, the want of fresh water and the renewal of the sea-water; in a word, the absence of oxygen and food in a sufficient quantity to nourish the oysters contained in the rearing ponds.

We would mention, as relating to this subject, a very remarkable fact. On the Canal de Rambaud there is a park, constructed under the direction of the municipality of Verdon, into which the scattered oysters gathered along the coast are deposited. The oysters which here find an asylum grow so rapidly that we have been enabled to present to the administration of the marine some specimens of them which in the space of less than three months had grown from 3 centimeters [$1\frac{1}{8}$ of an inch] to 8 and 9 centimeters [3 to $3\frac{1}{2}$ inches] in diameter.

The explanation of this phenomenon is as follows: The municipal claire, whose aquatic inhabitants no epidemic has ever disturbed, is situated at the level of the canal, receiving water from it twice a day, the water at most remaining stagnant only two or three days.

We have expressed the wish, and commended the matter to the en-

* We would here make an exception in favor of M. Bouchotte, who has established some very well managed cultural parks at Pointe de Grave. But these parks are not of the sort which we would see established. Another exception we would note, in M. Tripota, who himself instituted a series of very instructive and interesting experiments; and also in M. Peponnet. These are the only ones who may have established claires for artificial culture.

lightened attention of the minister of marine, that the work of deepening and cleaning the canals of Rambaud and Le Conseiller be undertaken. The realization of this idea, giving to the honest and interesting population along the Gironde an opportunity for which they have long waited, would permit them to practice oyster-culture on the spot at Verdon, and would have the effect of yielding up hundreds of hectares to industrial enterprise.

We will turn our attention to the Atlantic coasts and the shores of the Mediterranean. We are here brought into the presence of immense beaches and lagoons which no one has ever attempted to reclaim. Would it not, therefore, be found that the ponds of Berre, Caronte, Le Gloria, Mauguio, Palavas, Frontignan, Thau, Sigean, and Leucate are suitable for an enterprise of this kind? Does it not seem as if human industry might put an end to their sterility? The aquicultural industry, for example, for which they seem to have been designed, would it not be able to there establish and develop itself? We have studied the southern coast in detail, the aridity of which presents an afflicting spectacle, and in passing from one to another of the stations along these shores we have been convinced that they might become a field for active industry and a source of national prosperity.

This conviction I have endeavored to cause the members of the senatorial commission, in charge of the restocking of our waters, to share with me, in making the report to them of the investigation with which they had the honor to charge me in 1880.

The plan of the present report was limited exclusively to a single branch of aquiculture, having put aside everything which relates to marine pisciculture and myticulture [culture of mussels] in order to devote ourselves exclusively to the subject of the culture of the oyster. We may ask why the grand movement under the direction of the maritime administration and M. Coste, which determined the inauguration of the oyster industry on the shores of the ocean, did not extend to the French coasts of the Mediterranean. Are the waters not adapted to the precious mollusk; would they not be able to nourish it? Yes, most assuredly. The oyster is no stranger to our southern ocean. They were formerly to be had at Port de Bouc, at Cette, on the Rocher-d'Agde, at Narbonne, &c. We still find fine ones, not to speak of the French coast, at Toulon and in salt-water ponds in Corsica. Furthermore, we have seen magnificent beds established in the roads [bay] of Toulon, well ordered and managed, and which have nothing to envy in the splendid cultivations established on the shores of the ocean.

At Cette, in the canal connecting the lagoon of Thau with the sea, the cultivators have established floating parks of small dimensions, for the largest will not exceed forty square meters in area, on which they pile up and fatten more than a million oysters annually. We find, therefore, that the waters of the Mediterranean possess the qualities necessary to the growth and prosperity of the oyster.

The principal reasons why the ostracultural industry has not yet established itself on our southern coast are, in the first place, the ignorance of the art of aquiculture, for want of an example to follow, on the part of the maritime population of those districts; in the second, the poor success of the attempts already made; and, finally, the greater success of all those who devote themselves to the culture of the vine, the silk-worm, and madder. Times are now changed; different scourges have visited our southern provinces and ruined their secular industries. A more marked exodus of the population has now manifested itself for some years; the inhabitants with regret leave the land where they were born—they no longer yield them what will suffice for the needs of existence. This emigration would be arrested the day that a new industry came to furnish a field for their activities. Do we not know that oyster culture alone on our ocean shores regularly gives the means of existence to more than 200,000 persons? What immense resources would they not yield if the shores of the south could be taken up and developed in proportion to the extent to which they are capable?

But if it is necessary to cite the example of the western coasts, where the cultivation of the oyster has always been practiced, in an imperfect manner it is true; if the citation of this example were necessary, we repeat, to illustrate the splendid results which we would record, there is all the more reason why the southern coasts should be cultivated, where the people have always ignored the very first principles of oyster culture.

The examples of Toulon and Cette are too much isolated, and their influence extends over too restricted an area to provoke extensive imitation. It is asked if the success met with at those places could be as readily achieved in the Gulf of Marseilles, in the lagoon of Berre, and in those of Languedoc and Rousillon. Conscious of the utility of the efforts which have been made on the Mediterranean coasts, we have been authorized by the administration of the marine to make some experiments in the lagoon of Thau, in some of the estuaries of Languedoc, in the Gulf of Fos, and the lagoon of Berre, which have related especially to the artificial reproduction of the Portuguese oyster and its culture.

The work of artificial fertilization, using spawning adults which came from the Gironde, has, after some uncertainty, been clearly successful. M. Hardy, deputy of the administration of the marine at Cette, whom we instructed in our methods, wrote us, three weeks after our experiments were commenced, that the artificial fertilizations conducted by him resulted in producing mobile embryos in sixty-five cases out of a hundred. This was nearly the average attained at Verdon. All that was needed was to disseminate these larvæ in a favorable medium and to place collectors in proximity. The rock of Rouqueyrol, situated in the center of the lagoon of Thau, seemed to be favorable, and we had

the tiles coated with lime placed around it; but we did not consider the poachers, who, profiting by the cover of the night, destroyed and broke up our tiles and apparatus.

It did not seem worth while to repeat our experiments, seeing that the spawning season was already well advanced when the foregoing occurred. We no longer doubt, after what we have seen and the experience which we had in these matters, that the oyster will soon be propagated in the waters of the Mediterranean by the method employed by us. In regard to rearing, we have remarked that the Portuguese oyster adapts itself very readily to the waters of our southern coasts; but we have not noted with exactitude the rate of their growth, having protected our stock in a cage, a mode of culture which would appear adapted to these shores, where those deadly enemies of the oyster, the boring whelks, are found in multitudes.

Our conclusion it is easy to foresee. In conformity with what has been stated, we must acknowledge that the oyster industry may be developed and prosper on the French coasts of the Mediterranean.

We cannot close this report without considering the mollusk which has been under discussion in respect to its edible and commercial qualities. We know, however, that this species of oyster has its detractors. At one time these had reached the point of demanding its total extermination. The pretext was, as we have said, the pretended danger that it would interbreed with and affect the purity of our native oyster, but the true reason was the fear that it would replace the French oyster in the esteem of the consumers; in a word, it was a rival. We have shown what justice there was in this pretext. As to the real reason, that has no foundation. Has the sale and exportation of the indigenous oyster (designating by that name the flat oyster [*O. edulis*], for the oyster of the Tagus may now also be considered indigenous) diminished since the appearance of its rival? This does not appear to be the fact. Have our ostracultural establishments been encumbered by products which they could not dispose of? Not at all. The business is perhaps now less remunerative than formerly, because the number of dealers and producers is much greater; but all of the oysters that are reared or gathered are sold either in France or to other countries; and it is the same with the celebrated establishments, which find it impossible to supply the demand made upon them from all sides.

If the Portuguese oyster becomes the object of an important trade, and if it now contributes largely to the public food-supply, it will not be to the detriment of our native species. Because, relatively abundant, it is better known, and, because of its cheapness, it is procurable by those of slender means. These are the causes which make for it many partisans. Moreover, would the reasons urged justify the interdiction of what is to-day an important ostracultural industry? Is it necessary to reduce to misery, on account of some particular dissatisfied interests,

so many honest people who, thanks to this mollusk, feel, perhaps for the first time in a long while, that their condition has improved?

Is it necessary to reduce the unproductive lands which they have converted into fertile parks to their primitive sterility? Is it necessary to arrest that progress which seems destined to bring oyster culture into favor on those parts of the French coasts where it is not yet developed? And, from the point of view of political economy, would it not be most unreasonable to interfere with the production of a food-supply, under cover of the singular pretext that it interfered with and ruined the sale of a more delicate rival? Do we need to defend the harvesting of rye because wheat is better? Yes, it has been said that the Portuguese oyster was very much inferior to its rival in respect to flavor. This is possible, but this is a point to be decided by the consumer. The administration should have no preference, nor be orthodox in the matter of the flavor of oysters.

Do they not tell us that Americans have not the proper delicacy of taste because they relish the oyster of Virginia, which these persons would esteem but little more than *Ostrea angulata*? But it is not only in America that that species is relished, but all over Europe; in France, in England, and in the whole of Northern Germany, where it is brought both in the fresh state and canned.

We have no fears regarding the propagation of the Portuguese oyster in our waters, because, seeing the facility with which it is reared and its rapid growth, it occupies an important place as a food product, in consequence of which it will always find a ready market. If our ostracultural establishments would but produce a much larger quantity they might be exported in lieu of the American oyster, with the additional advantage that they would be fattened in the parks before they were taken to market. But in the present state of the industry we are not able to supply the demands of home consumption. Each year, vessels go in search of cargoes of them in the Tagus; but, in spite of this, they have great difficulty in obtaining them for our ostracultural stations, so that the important dealers in common or flat oysters, in view of this condition of things, have not agreed to supply more than a certain percentage of Portuguese oysters.

We are conscious, moreover, that the detractors of this species are becoming less numerous; that, as the culture of this mollusk tends to become general and cultivators devote themselves to it, they will not be of those who will realize the least of its benefits. Here, then, the new method is unfolded. We should not forget that we now occupy the first place in Europe as regards oyster culture; we should not neglect maintaining it.

In conclusion, it remains my duty to express my thanks to the functionaries of the marine for the enlightened and hearty assistance they have rendered me at all times, especially M. de Choisy, chief of the service at Bordeaux, and MM. Jouau, commissary at Pauillac; l'Hopital,

commissary at la Teste; Allégu, at commissary Martigues; and, finally, to M. the commissary Séné. We would also express to M. Hardy, at Cette, our sincere thanks for the zeal he has shown and pains he has taken to aid and second us in our efforts. Our thanks are also due to M. Curet, captain; to M. Blanchereau and M. Dutemple.

APPENDIX.

ANALYSES OF THE PORTUGUESE AND COMMON OYSTER.

Portuguese oysters, originally from Arcachon, or having been imported there at least a year.	<div style="display: inline-block; vertical-align: middle;"> <div style="display: inline-block; vertical-align: middle;"> Iodine . . Bromine.. Chlorine . </div> <div style="font-size: 3em; vertical-align: middle; margin: 0 5px;">}</div> </div>	.105 gram in every 100 grams of the soft parts of the animal.
Native Portuguese oysters of Verdon.	<div style="display: inline-block; vertical-align: middle;"> <div style="display: inline-block; vertical-align: middle;"> Iodine . . Bromine.. Chlorine . </div> <div style="font-size: 3em; vertical-align: middle; margin: 0 5px;">}</div> </div>	.11 gram in every 100 grams of the soft parts.
Common or French oysters (<i>O. edulis</i>) from the basin of Arcachon.	<div style="display: inline-block; vertical-align: middle;"> <div style="display: inline-block; vertical-align: middle;"> Iodine . . Bromine.. Chlorine . </div> <div style="font-size: 3em; vertical-align: middle; margin: 0 5px;">}</div> </div>	.057 gram in every 100 grams of the soft parts.

NOTE BY THE TRANSLATOR.—The resemblance of the Portuguese and American oysters is in some respects most striking. In both, the impressions of the adductors are dark purple, while in *O. edulis* it is almost invariably colorless. The muscle of both of the first-mentioned species is much more tender and evidently more readily digestible than that of the latter. *O. edulis* is smaller, and in every way inferior to both of the unisexual species.

The Portuguese oyster differs, however, considerably from the American in the form of the shell. The lower valve of the former is much more concave internally than that of the American, and the upper valve is often singularly bent to fit it. The internal-hinge border of the lower valve also frequently overhangs the cephalic end of the internal concavity of the latter to an extent rarely, if ever, met with in our species.

The body-mass is a very conspicuous portion of the soft parts of the Portuguese oyster. It is relatively much thicker from side to side than in any other species I have seen. The stratum of generative tissue is also of an extraordinary average thickness, actually far exceeding in proportional volume the same layer in either the American or common oyster of Europe.

It appears that the spat of *Ostrea angulata*, like that of the American species, grows much more rapidly than that of *O. edulis*. For data respecting the rate of growth of the spat of the American oyster, see my report, pp. 60-62, in the appendix to the Annual Report of the Commissioner of Fisheries of Maryland for 1881.